SOIL CONSERVATION

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Cattle and horses being driven toward corrals during round-up of McKenzie County Grazing Association.

LAND-USE ADJUSTMENT IN NORTH DAKOTA

By M. B. JOHNSON [1]

LAND-USE adjustment in North Dakota is one of the most popular subjects of discussion at farmers' and extension workers' meetings. Cropping of low-grade farm land, together with a series of dry years, resulting in a number of crop failures over a large section of the State, has caused farmers and Government officials to consider alternative land uses in the attempt to conserve soil resources and stabilize incomes of operators.

One of the best examples of land-use adjustment in North Dakota is in the western part of the State, within the Little Missouri land-use adjustment project in McKenzie County. In 1934, the Federal Government, through the land-utilization program now under the Soil Conservation Service, established this project involving a total area of approximately 766,000 acres, of which about 55 percent has been purchased by the Government. These lands are being made available to resident stockmen for grazing use. For several years preceding the initiation of the program, much of the land was tax delinquent and many of the occupants were on relief with no prospects of improvement in their economic condition. Most of the farms and ranches were too small or the soil was too poor to provide a living for operators under the existing system of use, even when rainfall and price conditions were normal. Living standards were necessarily low and proper educational facilities were lacking. Cost of maintaining schools in the area was higher than the districts' ability to pay.

A survey of the area preceding inauguration of the purchase program indicated that the prevailing type of agriculture was unsuitable to this particular section of western North Dakota. Taxes, levied to finance public expenditures including schools and roads, were far greater than the income from the land warranted. As a result, taxes were not paid and local governmental units along with individuals incurred a staggering load of indebtedness.

The problem of land-use adjustments involved: (1)

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Determining the best use of the land which would prevent further soil deterioration, taking into consideration existing soil conditions, climatic factors, and available markets; (2) determining the probable amount of land necessary to support a family under the proposed system of use; (3) designing a program for adjustment of the population to land resources of the area to ensure a continuous and satisfactory income to remaining operators.

The survey further indicated that much of the land under cultivation in the area covered was unsuitable to farming because of poor soil and rough topography, and that this type of land should be permanently retired from cultivation and returned to the production of perennial grasses. The least hazardous of any known type of agricultural production in this area is the production of native grasses that can be converted into beef, mutton, wool, and milk and augmented by a limited amount of cultivated crops on more favorable soils for supplementary stock feed, garden produce, and some specialized cash crops.

The survey also revealed that approximately twice as many families resided in the area as the land resources could reasonably support. Before actual optioning of land was started, it was necessary to determine which of the resident operators had range-livestock experience and inclinations toward that type of farm life with apparent managerial ability. Approximately 55 percent of the operators had these qualifications, and wished to remain on their land. The other 45 percent generally desired to sell and move from their farms. Their holdings were purchased first. Operators who were undecided on what course to take but had some qualifications for success were further consulted and some of them are still living in the area. Ninety percent of the land recommended for purchase was bought or optioned within the first 8 months of actual land-acquisition activities. Of the 241 families who moved from McKenzie County farms, 220 are still in the State, most of them on better farming units than before purchase of their lands.

All operators remaining in the area have benefited through increased returns. They will continue to benefit in a larger measure as their herds are built up to the carrying capacity of the range. By converting the area to range-livestock production, it was found that many acres of grass were too far away from available livestock water supplies to permit uniform grazing of the range. A program of land development was inaugurated in 1935 to correct this deficiency. Under this program, 40 reservoirs have been constructed; 134 springs have been developed and watering tanks installed; 23 wells were drilled, windmills erected, and storage tanks constructed for a permanent water supply; 438 miles of barbed-wire fence have been built; and 3,700 acres of abandoned farm land have been seeded to perennial grasses. A fence has been constructed on the outside boundaries of the area. This fence, supplemented by a number of division fences dividing the area into 14 pastures, is facilitating good land-management practices by confining live-stock within designated areas and preventing trespass of outside stock.

A large number of farm buildings and fences were acquired with the land. As rapidly as land is purchased, buildings and fences are either sold to the highest bidder and removed from the land or are salvaged as part of the development program and sold or used in construction on the project.

Following the establishment of the land-utilization project, a grazing association was organized. Membership is composed of local operators who elect their own officers, fix land-use regulations, and assign grazing privileges to members according to priority, dependency, and commensurate property qualifications. The association leases Federal, State, and county lands for a period of 10 years, and privately owned land for as long a period as feasible.

Certain laws enacted by the 1938 North Dakota legislature should have far-reaching effect in making possible wise land use. These laws make it possible for county- and State-owned lands to be leased for periods up to 10 years. The McKenzie County grazing association can now obtain long-time leases on State- and county-owned land that formerly was leased for 1-year periods only. The rate of stocking, or grazing capacity of the land, is determined by the Government. In leasing Federally owned lands the association agrees to graze land under its control in accordance with the recommended grazing capacity.

Properly managed economic-sized units, a State grazing law that encourages protection of grasses, and cooperation of individual ranchers in instituting conservation practices have resulted in better grasses and higher carrying capacities for livestock. The operators in the area are pleased with the adjustment program. They now have a degree of security of tenure never before experienced under the old system of year-to-year leases. If future studies definitely indicate that such an increase will not damage grasses, it is expected that, with range improvement, the carrying capacity which is now limited to one animal unit for each 25 acres 10 months per year, will soon be increased.

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HIGH CROP-STUBBLE AND SNOW CONSERVATION

By V. H. FLORELL [1]

PROBABLY none of the conservation practices used in the Great Plains region will be more productive of results than those designed to conserve moisture. If moisture is conserved, crop production is more certain, and the production of vegetation results in protection of the soil from erosion. The practices, contour farming, contour strip cropping and pasture contour furrowing, are designed primarily to conserve precipitation run-off. These practices, however, will not exert the maximum effect in moisture conservation from snowfall, a source of considerable importance, without proper maintenance during winter of a reasonably large amount of crop residue for holding snow on the land.

The northern Great Plains are favored by fairly high average snowfall, but in common with other portions of the Plains region they are subject to strong winds, frequently of high velocity. Most of the snow storms are associated with high winds, so that a great deal of drifting occurs. Snow that might be held on the fields and pastures now commonly is blown on to roads and highways, making them impassable for traffic. A slight alteration in agricultural practice in handling cultivated crops would do much toward conserving the snow by holding it on the fields where it will be useful.

To give a more definite understanding of the possibilities for snow moisture conservation, average data on precipitation, including snowfall and wind velocities, are presented and discussed in this article. Averages for the following localities were obtained from data reported in the United States Weather Bureau Climatic Summary for 1930: Havre and Miles City in Montana; Bismarck, Devils Lake, Ellendale, and Williston in North Dakota; Huron, Pierre, and Rapid City in South Dakota; and Cheyenne, Lander and Sheridan in Wyoming. The records cover periods of 37 to 61 years.

The elevation above sea level, which exerts considerable effect on the relative proportion of snowfall, ranged as follows for the points in the different States: 2,371 to 2,483 feet in Montana; 1,451 to 1,869 in North Dakota; 1,282 to 3,231 in South Dakota; and 3,790 to 6,057 in Wyoming.

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The average annual precipitation in inches by States for the points mentioned in each State was as follows: Montana 13.56; North Dakota 16.99; South Dakota 18.39; Wyoming 14.52. The average snowfall in inches was: Montana 34.1, North Dakota 33.0, South Dakota 30.7, and Wyoming 60.4, with water contents of 3.40, 2.98, 3.00, and 5.73 inches respectively. The average percentage of snow water in terms of the average annual precipitation was 17.8 for North Dakota, 16.5 for South Dakota, 25.0 for Montana, and from 35.0 to 50.0 in Wyoming.

The average annual wind velocity in miles per hour (from 24-hour daily records) for the Montana stations was 7.9; for North Dakota it was 10.5; and for South Dakota 9.6. At Lander and Sheridan, Wyo., which are situated in or near the Rocky Mountains, it was 6.0; and at Cheyenne, which is out on the plains, 11.0 miles per hour. The maximum wind velocities during the 6 months, November to April, at the various stations ranged from 46 to 63 miles per hour.

With moderately high annual wind velocities at the various stations, and with usually stronger-than-average winds during winter and occasional storms of gale proportions, it is readily understandable that snow is almost certain to pile up in drifts during storms. Only rarely does snow fall and lie in place without drifting. Considering the climatic conditions that prevail in the area and the amount of moisture from snow that ordinarily might be conserved, it is clear that considerable additional moisture can be made available for the growth of plants.

In the Plains area, grain crops are harvested by means of binders, headers, or combines. Because of the limited rainfall, crops often are short, and it is necessary that they be harvested with less stubble than is desirable. Yet even in more normal seasons, when reasonably tall straw is produced, stubble not more than 3 or 4 inches high is frequently seen—probably the result of long-established harvesting practice. Considerable acreages of row crops also are grown and where such crops are used for fodder the ordinary practice is to harvest the stalks and leave only 4 to 6 inches of stubble.

In winter after a snowstorm these closely harvested fields usually are noticeably free of snow. On the other hand, where a 10- to 12-inch stubble is left, the

field may be completely filled with snow after a moderately heavy storm. Along the closely harvested fields, highways are likely to be badly drifted; along fields having high stubble, roads are much more likely to be open. Cornstalks left standing on the ground usually prevent most of the drifting, so that snow ordinarily is seen at a comparatively uniform depth over the entire field. Tall grass has the same effect as high stubble. Grazing lands in good condition retain much more moisture than those that are overgrazed.

It is not always possible to leave grain stubble as high as indicated by the figures in the paragraph above, because in some seasons the entire crop may not be higher than 12 to 15 inches. Nevertheless, it is to the farmer's advantage not to harvest the field too closely; if necessary, the cutterbar may be set high enough to leave a few lower heads of grain in the field so that an effective moisture-conserving stubble is retained. The additional moisture saved in one season may make considerable difference in the height of straw the next season when all the heads may be harvested. The aim in harvesting at all times should be to leave as high a stubble as possible within reasonable limits.

In corn or sorghum row crops, stubble of 12 to 15 inches will do a great deal toward holding drifting snow. A practice now being followed by some farmer cooperators in Soil Conservation Service erosion-control areas is that of leaving on the field 4 to 6 rows of corn or sorghum out of every 16 or 20 rows. The object is to provide windbreaks that lessen soil erosion by reducing surface wind velocities, and also to trap snow. In much of the northern Great Plains area, the efficiency of the standing rows, where contour farming is not practiced, will be greatest if the crop rows run as nearly as possible at right angles to the prevailing direction of the wind.

To determine the relative amount of moisture penetration from snowfall on bare and covered fields, in the early spring of 1937 a number of soil borings were made on the Wolsey demonstration area near Huron, S. Dak., on fallowed land (plowed) and on adjacent land covered with about a 6-inch growth of Russian thistle. The fallow was entirely bare of vegetation. Rather limited summer precipitation had fallen after the land was fallowed in June 1936, and from 15 to 18 inches of surface-soil moisture was present in the fallow when the winter season began. The thistle field, on the other hand, had only about 8 to 10 inches of moisture in the surface soil as a consequence of soil-moisture depletion by the thistles.

The snowfall recorded at Huron during the winter was approximately 40 inches. The spring thaw occurred in late March and early April. The average moisture penetration in the thistle field was 33 inches, and on the fallow ground 22 inches. On the fallow, most of the winter's snow had blown off, while in the thistles a great deal of it was retained. On the fallow, the increase in depth of soil moisture from the winter precipitation was only 6 to 8 inches; whereas, on the land having the thistle cover, the increase was from 23 to 25 inches. Low moisture penetrations also were observed in a number of other fallowed or fall-plowed fields in the Huron area in the spring of 1937.

A more definite idea as to the quantity of snow and snow moisture that can be trapped by crop residue of different heights—in this case grain stubble—may be had through a study of the data from snow and snow-water measurements taken in undisturbed grain stubble fields and, for comparison, in fall-disked stubble fields with observations on adjacent summer-fallowed fields on the Soil Conservation Service demonstration project at Bottineau, N. Dak., on February 27 and 28, 1939.

The total amount of precipitation (water) recorded for the three current winter months(December, January, and February) at the North Dakota School of Forestry at Bottineau was 0.99 inch. For three Soil Conservation Service farmer observers it was as follows: Rudolph Feller at Kramer, 0.63 inch; Clara Richwalski at Gardena, 0.49 inch; Arthur Vollmer, Willow City, 0.67 inch. On the demonstration area this amounted to about 12 inches of snow at Kramer, and 15 inches at Willow City. A great deal of drifting occurred during February.

The average depths of snow and snow water for two general locations about 15 miles apart, east and west, were as follows: At Kramer a field strip having a 6-inch undisturbed stubble had an average of 4.6 inches of snow with 1.10 inches of water; two fields having 12-inch stubble, had 9.9 inches of snow with 1.69 inches of water. It should be recalled here that the snow measured represents the winter's accumulation, which was settled and packed and had a relatively high water content.

Near Willow City two fields with 10-inch undisturbed stubbles had an average of 7.5 inches of snow with 1.94 inches of water; one field with a 12-inch stubble had 10 inches of snow with 2.36 inches of water; and a 14-inch stubble field had 11.4 inches of snow, with 2.46 inches of water.

Near Kramer, a fallowed field strip (east-west) free of vegetation and worked with a duckfoot for the last operation, adjacent to an undisturbed stubble field

where measurements were made, was almost completely bare. A similarly fallowed north-south field strip, adjacent to a sampled stubble field, also was mostly bare except for a drift along the stubble on the west.

Since on the average the highest yields of spring grains are produced from the early seedings, it has been a fairly common practice with farmers in this section to fall plow for small grain in order to be able to sow a larger acreage the following season. Farmers are beginning to observe that fall plowing has not given as good results as spring-plowed stubble. It seems fairly evident that the conservation of snow moisture in stubble, together with the protection it affords the soil from erosion and evaporation losses, plays a significant part in producing the differences noted. Without going into the relative values of fall plowing and fallow in crop production, the comparison between the amount of snow retention in high grain-stubble and on fallow emphasizes the value of crop residue in snow-moisture conservation.

The value of a special disk for fall tillage, to leave most of the crop residue on or near the surface of the soil, is being studied in its relation to soil and moisture conservation. The disk is set to cut the soil deeply, so as to provide a large moisture-absorbing capacity. After disking, much of the stubble remains partially erect and serves to catch snow, reduce evaporation, and to prevent soil blowing. Naturally, the amount of residue present will materially affect results. In the use of this implement for fall tillage, moderately high stubble is very important.

The snow coverage on several fall-disked stubble fields was measured. Here the special single disk, heavily weighted, had been used, and on all these fields the disk was set at a sharp angle so as to cut deeply and thoroughly. In this operation the field is left with moderately high ridges having depressions or valleys between.

A field strip near Kramer, with a rather thin 6-inch stubble that had been fall-disked with the special disk, trapped very little snow. This field was about half bare, with the remainder covered thinly with snow and a low drift near the buffer strip on the west.

The fall-disked fields on cooperators' farms near Willow City were well blanketed with snow—the result of their covering of fairly dense stubble of 10 to 14 inches. Much of the stubble remained partially erect on the disked fields. Snow measurements were made on both ridges and midway between ridges, in all fields. The depth of snow in depressions averaged 7.8, 10.0, and 8.5 inches respectively in stubbles of 10. 12, and 14 inches, with water contents of 2.41, 2.40, and 2.28. The average depths of snow on the disk ridges in the three fields were 1.8, 3.6, and 0.0 inches.

From the above results it is seen that considerable quantities of snow moisture may be conserved by leaving moderately high stubble on harvested fields. Where the snow is lodged, the percentage of accumulated snow water that finds its way into the soil naturally varies with the nature of the thaws and the receptivity of the soil. On the moderately level fields in this section of the Plains the moisture absorbed usually is considerable.

Another important purpose served by stubble on the ground in winter is that it protects soil moisture from evaporation. On the average, the humidity of the air during zero and subzero temperatures is low. Strong winds during such periods remove considerable amounts of soil moisture. This may be verified readily by examining and comparing plowed fields and adjoining stubble fields, preferably on loam or sandy loam soils, after several windy days in winter following a light snowfall. Surface-soil moisture is almost certain to be found anywhere in the stubble, while on plowed or fallowed land a loose dry mulch an inch or two deep frequently is found at the soil surface.

Frequently large straw piles are seen in winter in harvested wheat fields of the Plains country. It is true that they are to a large extent a source of much needed roughage for cattle, but in many instances they merely are burned the following spring to clear the land for succeeding crops. A considerable proportion of this straw could be left as stubble in the fields to aid in conserving snow moisture as well as soil.

Thysell,[2] in a recent bulletin on the conservation and use of soil moisture at Mandan, N. Dak., and covering results of 20 years of continuous investigation, reports that among other factors the quantity of water available for crop use in the soil at seeding time "is directly related to the presence or absence of stubble cover on the surface."

In a study of the annual and average quantities of precipitation during the major parts of the fallow period, and the percentages of it saved in the surface 6 feet of soil under alternate cropping of wheat during the period of 1914 to 1934, it was found that an average of 4.48 inches was saved during the entire fallow period. For the 19 fallow periods, 2.31 inches were saved during the first major period, that is, harvest to seeding time. This represented the fall and winter following harvest, when the fields were covered with

[2] Conservation and Use of Soil Moisture at Mandan, North Dakota. By J. C. Thysell. U. S. Department of Agriculture Technical Bulletin 617. 1938.

stubble which conserved snow moisture and reduced loss of moisture from evaporation. During the second fall and winter period, when the fields were bare as a result of the fallow operations, 0.76 inch of moisture was saved. During this period the presence of water already stored in the soil, as well as the lack of stubble protection, contributed to the comparatively low amount of water saved during the time of the last major period before seeding. The average saving during the second period, or during the time of tillage operations for fallow, was 1.42 inches.

These experiments, in which actual moisture determinations were made several times during the growing season, emphasize the value of a stubble cover in conserving moisture.

Thysell also found that in the production of wheat and corn "Approximately one-half as much water is used during the dormant period, as is used during the growing period. The lowest average use comes under treatments having stubble cover, and the highest use comes under treatments where the ground surface remains bare, such as fall plowing, corn ground and summer fallow. When ground during the dormant period is covered with wheat stubble, from 64 to 68 percent of the precipitation is used. Under corn stubble and on fall plowed corn ground, 76 percent of the precipitation is used. On fall-plowed wheat land, 80 percent is used, and under fallow, 90 percent is used."

Duley and Kelly[3] in experiments at Lincoln, Nebr., have demonstrated the value of straw residue in promoting the penetration and absorption of moisture by soil. This information has a direct bearing in the problem of increasing the moisture content of soils low in organic matter.

The preservation of a reasonably high crop-stubble protects the soil from wind as well as water erosion. While on the average only a very limited amount of erosion occurs in the winter when the ground is frozen, the stubble protects the land during late fall and early spring when the winds very often are high.

Another important use of this vegetative cover is that it serves as a source of humus for the soil. It should be remembered, however, that the plowing under of excessively large quantities of straw may depress yields.

A reasonably large crop-residue cover in winter likewise results in added protection for wildlife. Birds are of considerable economic importance to agriculture, in that they tend to hold in check insect pests that infest crops.

With proper utilization of crop residue on much of the cultivated land of the northern plains, it should be possible to conserve from 2 to 3 inches of the snow water which now in most instances is very largely lost. The farmer may feel that he can afford to leave only as little feed as possible in the field; yet, if some attention is given to holding the winter snow on the land, it will enable him to grow a larger feed or other crop the following year.

[3] F. L. Duley and L. L. Kelly, "Effect of Soil Type, Slope, and Surface Conditions on Intake of Water." Research Bulletin 112, Agricultural Experiment Station, University of Nebraska, Lincoln, Nebr. May 1939.

LAND USE IN NORTH DAKOTA

(Continued from p. 222)

The adjustment program, involving purchase, development and management of the land, has met with general approval from all groups in the county. Businessmen believe it is better for them to have a smaller number of self-supporting, prosperous families in their trade territory than a larger number of operators with low purchasing power. The sportsmen of the State are in favor of the program, as wild game is being protected under a system of game management supervised by the Soil Conservation Service; this management ensures continuous good hunting of native upland game birds as well as the imported ring-necked pheasant and Hungarian partridge. The larger stock water reservoirs have been stocked with game fish, and a limited amount of food-bearing water plants for water fowl have been planted. Deer and antelope are found in limited numbers and these will increase under a system of proper game management.

Public officials favor the program because public expenditures have been reduced. While some tax-paying property has been taken from county records, county officials believe that the county's share of revenue received by the Government for the use of project lands will equal the amount of taxes actually collected from such lands during the period preceding the purchase program. The closing of 16 rural schools as a result of population adjustment has resulted in a saving of $12,800 annually to the taxpayers. This has been done without impairing school facilities for children remaining within the area, and in many instances, it will be a factor toward improving educational advantages. Reduction in various forms of relief and subsidies formerly paid to families who have moved from the area has been the largest single factor in reduced public expenditures.

REHABILITATION OF OREGON RANGE

By FRANK B. HARPER [1]

NOTICEABLY concrete progress in the Jefferson County, Oreg., land-utilization project is attracting the attention of central Oregon ranchers and agriculturalists. The project, now in its fifth year of operation, includes 180,000 acres of land which prior to and during the World War period were subjected to unprofitable settlement for dry-land grain farming. The land is now being returned to its best use as livestock range.

Grazing, held down to the safe carrying capacity of the range, and the reseeding of thousands of acres of abandoned farmland to grass are cited by A. M. Christenson, project manager, as major steps taken to conserve this important block of Oregon's acreage. The available grazing is distributed in cooperation with stockmen who are eligible for grazing permits in such a way as to maintain on a sound economic basis as many operating units as the resources in the area will permit.

Many miles of sturdy fence dividing the range lands into usable pastures, dozens of springs and other sources of stock water, and miles of trails enabling livestock to reach the water of the Deschutes and Crooked Rivers are among other developments that may be mentioned as bringing about the land-use transformation that is gaining the attention of ranch operators in central Oregon.

In 1934, officials of State college and the experiment station, the State land-planning board, and members of the State relief administration, proposed Government purchase and development of submarginal lands in central Jefferson County. Many of the farms were abandoned and were blowing down to the subsoil to which depth they had been plowed in the attempt to sustain crop production without irrigation in an area which has an average yearly moisture of 8 inches or less. Other thousands of acres were in nearly as hazardous a condition as a result of unlimited grazing that had kept the bunchgrass eaten off to its roots until it gave way to cheat, or to nothing at all. The central Oregon area was chosen, secondly, because the conditions represented those found over a larger territory extending north and east through all or parts of Wasco, Sherman, Gilliam, Morrow, and Umatilla Counties in Oregon, and over the line into Washington.

Since the Central Oregon project opened in January 1935, approximately 100,000 acres have been bought. Another 2,000 acres have been recently optioned for purchase. The project does not interfere with development of the proposed north unit of the Deschutes irrigation project, but does promise to complement it effectively in the eventual over-all agricultural development of the area, through making grazing land available to farmers who will operate the lands to be irrigated. No purchases have been made in the 50,000 acres of wheat land lying on either side of United States Highway No. 97 through Madras, Metolius, and Culver, which will eventually come under irrigation when the Deschutes irrigation project is completed.

The big problem in this territory, as Mr. Christenson explained it, is the making of adjustments that will permit livestock operators to provide themselves with properly balanced units through assured spring and fall range and carry-over feed. The land-use development has been based on the proved theory that these needs can be met with practices that will at the same time stop the destruction of soil resources. Accordingly, some 14,000 acres of land, formerly cropped, have been seeded to hardy crested wheatgrass. Another 2,000 acres were selected to be seeded this fall, and 20,000 acres more in the future.

Four hundred miles of rusting fence that enclosed farm units ranging from 40 to 1,200 acres and averaging 250 acres have been removed, and another 45 miles of such fencing will be taken out this next year. New pasture boundary and drift fences totaling nearly 150 miles have been built, and 30 miles more will be added this year. Separation corrals, a sheep trail, and cattle guards further help permit holders to obtain maximum use of the range without abusing it.

Operators who depended upon this grazing in the past are given special consideration in distributing the available grazing privileges. The range is being stocked on safe carrying capacity, and the grazing permits are based on farm and ranch surveys made earlier to determine operators' needs. Among the stockmen benefiting from this plan are some of the families who moved from the project area to adjacent communities, as well as the 8 ranchers remaining inside project boundaries after 49 had relocated.

(Continued on p. 231)

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Erosion-Control Lessons From Old-World Experience

V. THE LOST AGRICULTURE OF TRANS-JORDAN

By W. C. LOWDERMILK [1]

FOR a soil conservationist, the study of Trans-Jordan as it is today, compared to what evidence reveals it must have been during its Golden Age of agriculture, is most revealing and serves as a warning that cannot be ignored. Generation replaces generation in population, but fertile soils once gone cannot be replaced, or the remaining productivity saved for the future, without a change in the attitude of mankind toward his occupation of the earth. A new national ethics and economics must be developed which will recognize that a nation has a moral obligation to the earth and its future inhabitants, and which will coordinate the national interest and individual initiative in the use of land. Second to our descendants, our most direct link with the future is through the land, in the abundance or the poverty which we pass on to those who follow.

During the past 6 years exploration and spade work of archaeologists have turned back the pages of history in Trans-Jordan 3,000 to 4,000 years, and brought to light the amazing agricultural development and civilization of the Nabataeans. Today, more is known about the Golden Age of agriculture and the former populations in Trans-Jordan than has been known since the Nabataean civilization was blotted out some 1,200 years ago by the Arab invasions. Petra, the Nabataean capital, was destroyed—it slumbered and crumbled in the fastness of its desert gorge, unknown to the world until its spectacular rock carved tombs were rediscovered in 1812, by the Swiss explorer, John Lewis Burchardt. Recently, Dr. Nelson Glueck, director of the American School of Oriental Research, has been directing excavations of the Port of Solomon, used later by the Nabataeans near Aqaba on the Red Sea.

The Nabataean civilization was built on agriculture and trade. Elaborate houses, public buildings, water supplies, and public baths represented by excavated

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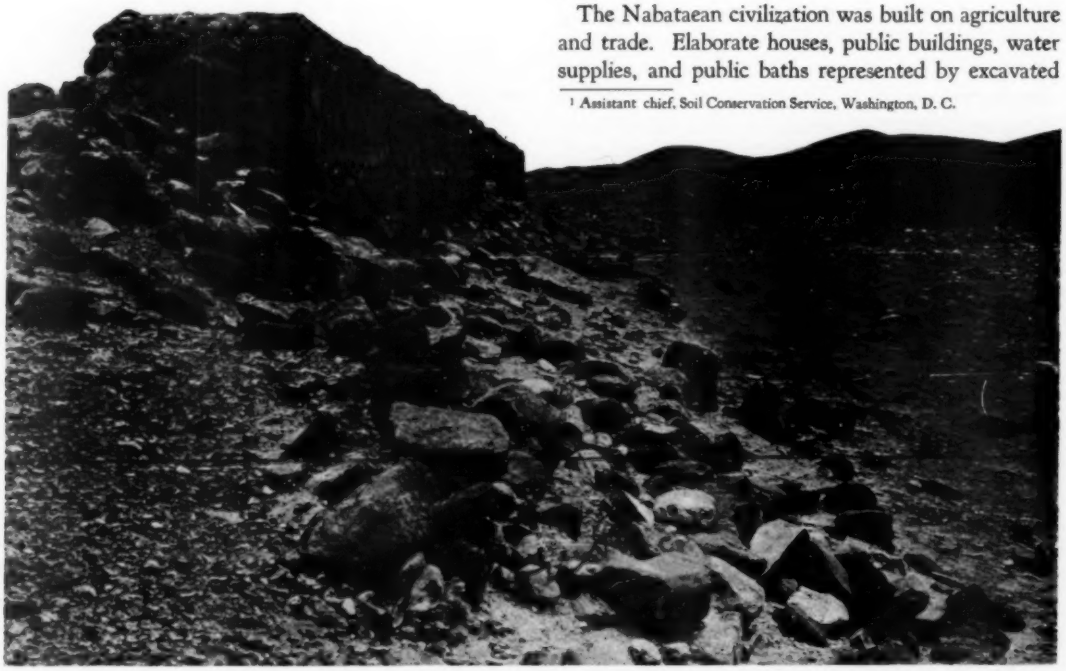


An ancient dam which once impounded waters for the Roman city of Ma'an. When the reservoir silted up the stream cut out a new channel to one side.

ruins show high skill and technique in construction and adornment. Now all that remains of this glorious past of beautifully built cities and carefully cultivated fields protected by rock-wall terraces, are crumbling ruins. Abandoned fields, ruins of terraces, and remnants of former forests reveal a change from ancient prosperity to modern poverty and decadence.

The sweep of human struggle from the first groping of the food gatherer to modern times is filled with rises and falls of cultures and empires. Throughout a long period of 6 to 7 thousand years from the late Stone Age, occur two epochs of "silent centuries" of which few remains of permanent construction of houses, cities, or works are found. They occur from about 2000 to 1300 B. C. and from A. D. 1500 to the present; these are two epochs of tent dwellers. Hords of fierce nomads had at the beginning of these two epochs destroyed the works, cities, and agriculture of advanced civilizations, but they did not rebuild. They continued their tending of flocks and pitched their tents where water and grass might be found. Most of the advances in the use of land and conservation of water fell into disuse. About 1300 B. C., late Bronze Age people began a period of building cities, usually located near big springs, and restored a sedentary agriculture. Evidence is found about a Bronze Age site near Jerash which indicates that terracing was used by the inhabitants at that time.

The children of Edom still tend their flocks among broken-down terraces and watch the yearly rains carry away the remaining soils from their cultivated patches. They still scatter scanty seed grain on unplowed land after the first rains and plow it in with a primitive plow, and pray to Allah for the harvest. The yields are from threefold to fivefold in average years, sometimes as much as fifteenfold in the best remaining ground. Some years scarcely are the seed recovered in the harvest. They eke out a meagre existence and care little for permanent abodes. Their hundreds of goat's-hair tents appear as huge bats' wings outstretched in the ravines or on the hills. Herds of goats appear as flocks of blackbirds searching among the rocks for scanty vegetation and roots.

The Nabataean empire extended from the Red Sea to Damascus, and an unknown extent into Arabia, but it was never able to overcome the Greek league of 10 cities known as Decapolis, covering the western-central area of Trans-Jordan and part of Palestine, The origin of the Nabataeans is obscure, but they are believed to have been a Semitic tribe of nomadic Bedouins of Arabia, who swept over in a wave from the hungry and thirsty desert. After their conquests of the kingdoms of Moab and Edom they settled down to a fixed abode and developed a remarkable agricultural civilization.

As has occurred many times in these lands, the wild desert men, always hard pressed for food, invaded the cultivated areas. They replaced the former settlers and followed agriculture until they in turn were supplanted by another wave of hungry desert people.

Prior to Dr. Glueck's survey and study of about 500 Nabataean sites, it was the general opinion that the inhabitants of Petra and other large Nabataean centers owed their wealth chiefly to the commerce of caravan routes. Petra, as capital of the Nabataean kingdom, was known as an important caravan center, connecting Egypt and Arabia on the south, Syria on the north, Gaza, the port on the Mediterranean on the west, and Babylon to the east. But these field studies, in the past 6 years, have disclosed the remains of a former intensive and extensive cultivation of the land surrounding Petra and other centers. Broken-down terrace walls in the catchment area of Wadi Musa, draining into the gorge of Petra, bespeak of a former intensive cultivation of this entire area. The valley of the Wadi Hesah, also shows evidence of having been terraced over the entire extent of its gentle to steep slopes. It may be assumed that the more productive lands of the plateau were in full use before such elaborate effort would be made to cultivate slopes of gradients up to 80 percent.

These works of intensive land use have fallen into decay and disuse. Erosion has followed close behind the nomad destroyer of the inhabitants and houses of settled communities, and has completed the destruction by washing away the soils, and filling the drainage channels with erosional debris.

Striking evidence of this is found in the Sik or gorge leading from the catchment area into the site of Petra. A remnant of a former fill of erosional debris was left in the gorge 3 feet above a water conduit cut into the red sandstone wall, now 7 feet above the floor of the gorge. This remnant indicates that at some former time, after the abandonment of Petra, storm run-off draining the catchment area had brought down and deposited erosional debris to a depth of 10 feet above the present canyon floor level, and that still later, the storm run-off had eroded out this material to the present level.

Many such successions of the filling and cutting of drainage channels have been observed by the writer in China and in the United States. They are only ob-

vious symptoms of a cycle of destructive soil erosion. At first, when erosion of sloping lands is highly accelerated, the streams of storm run-off are overcharged with soil and debris, as they come off the steeper slopes and, on reaching the lesser slope of the main drainage channel, they are unable to carry the load of much material; they become overloaded and drop a part of the material and fill the channels. As time goes on the readily erodible soils of the slopes are washed away or natural vegetation gains more control. Streams of storm run-off then flow down the slopes carrying less material than their capacities and pick up deposits of erosional debris. These deposits are cut out and moved farther downstream to be deposited again in wider and gentler reaches of the channel.

From this evidence in the Sik and in the catchment area of formerly highly terraced fields, soil erosion reached a high rate in the Wadi Musa catchment on the abandonment of agriculture and the break-down of terrace walls. But as the terraces were washed out and natural vegetation gained more control, storm waters ceased to be loaded to capacity and began to cut and carry farther downstream the deposits in the Sik or gorge, as shown by remnants of former fills. The highly developed agriculture of the Nabataean period was neglected after the nomad conquest, and soil erosion brought about destruction of the land. This, more than the cessation of caravan trade, in my opinion, explains the extinction of Petra and its unique civilization.

The Nabataeans not only intensified agriculture in the more favorable areas, but pushed cultivation and intensive use of the range farther out toward the desert than ever was done before or since. They were able to do this because of their ingenuity in the conservation and utilization of rain waters. Thousands of cisterns were a part of their program for making habitable the year-round areas which otherwise would have been impossible in dry seasons. Some of these cisterns are very large and are dug out of the solid rock, with only a small opening for the water to be drawn out. Many of the fortresses on hilltops bordering the desert had cisterns sufficient to supply water for a hundred or more people the year-round. Some cisterns were made of rock and plaster and had conduits which made water available for irrigation. Some were definitely designed and placed for the use of flocks so that they might feed high up on the hills without going great distances to water. Near some cisterns were found stone troughs for watering herds. In some sites every dwelling appears to have had its own cistern and to have had no other source of supply, while others appear to have been needed to supplement the water from a spring because of large numbers of the population. The people were most ingenious in utilizing a depression to form a reservoir, by building additional walls to enclose it. Rain waters were collected from slopes and rock surfaces by ingeniously located banks and diverted into cisterns.

It is significant that the same rainfall of today is sufficient to fill these cisterns to capacity. A cistern was found on one occasion to be filled largely with water as late in the summer as August. In one of the largest cisterns in Petra, blind fish were found, giving evidence of long existence. About the High Place, or Citadel of Petra, which served as a refuge for the inhabitants during attacks, the great rock surface of the mountain top was converted into one huge catchment area for collection and storage of rain water in cave cisterns provided for a long siege in an otherwise waterless area. The Nabataean villagers sometimes built cisterns out on the desert, in places known only to themselves, to which they might flee in times of danger or attack.

In the great Wadi el Hesah, there is today a green cultivated area on a slope, which presents a striking contrast to the barren rocky surroundings. The entire slope once was terraced and cultivated. There are remains of ancient rock conduits to carry the spring water out to some former cultivated terraces. But today the spring waters flow by gravity at will, and a large area is swampy and seeping with water among the weeds and rushes. The water is only partially used today. A good stream is flowing in the Wadi, but the former irrigated terraces are broken and unused; sand and debris from flood waters have piled upon what otherwise might have been garden lands. Numerous olive and wine presses of stone have been found on slopes of this Wadi, which formerly were cultivated. Many of the ancient terraced gardens are now thorny wastes. With terrace walls neglected for centuries, much of the good earth has washed away exposing the ugly naked rock and adding ruin to the country.

Many ancient sites show remains of terraces, but only a few are still in use. Most of them are broken down and the soils have partially or entirely washed away through the gashes and breaks. Modern farmers are, for the most part, content to rely upon the work of farmers who preceded them by 2 thousand years or more, and do little to repair or rebuild terrace walls—just as practically nothing is done to make available the hundreds, or even thousands of ancient cisterns which, with cleaning and repairs, could be

put to service for conserving storm waters for dry seasons.

On the basis of his surveys, Dr. Glueck estimates that during the early Iron Age, about 600 B. C., Trans-Jordan had a population of 450,000 as against 300,000 today, but that the greatest density of population occurred during the Nabataean period in the time of their independence and later under Roman and Byzantine domination. This period lasted about 1,000 years, approximately from 300 B. C. to A. D. 700. The population during that period is estimated to have been more than three times that of today, or about one million inhabitants.

Extensive forests once covered the highest parts of the Trans-Jordan Plateau, whereas today only an occasional Butum or Terebinths tree escapes the charcoal pit, and grows up among the ruins on an ancient site. If it covers a grave it becomes a sacred tree and is allowed to remain, though it is browsed by goats as high as they can climb or reach. Near Jerash, at Ajlun, a considerable forest area still remains where trees are rapidly being cut and the rocky soil is being plowed and sown to grain. Soil erosion may be noted on such sloping fields, and abandoned fields where the land has been impoverished by erosion. The process of shifting cultivation still moves on. The ancients reserved this land for forests, and the area appears never to have been cultivated before.

Near Petra, at Al Hish, in the region of Mount Seirat, are the remains of what appears to have been an extensive forest at an altitude of about 5,000 feet. Doubtless, here grew the timber which was transported to Ezion Geber on the Red Sea and used to build Solomon's Red Sea fleet. During the World War, when the Turkish railroad was cut off from its usual coal supply and was in need of fuel, a branch line was run to this forest area, and the remaining trees were slaughtered for fuel without regard to restocking. Happily, a few specimens remain to show what the forest stand was like, but the trunkless bases of the old giants are like great slabs of black stones scattered about over the land.

Today, all the country surrounding Petra is barren and desolate. A few irrigated trees and orchards on the terraces of Elji are all that remain of what were once famous and extensive orchards, vineyards, and gardens. Four other nearby ancient sites with remnants of terraces also appear to have been agricultural areas supplying the markets of Petra.

REHABILITATION OF OREGON RANGE

(Continued from p. 227)

The fee charged for grazing is approximately the same as that charged in the adjacent forest grazing areas. Twenty-five percent of the collections are paid by the Federal Government to the county to be used for school and road purposes.

Stock-water development, to facilitate more even use of the range, thus far has included 50 springs and windmills installed with troughs, more than half a dozen catch-basins or small earth dams for storing run-off water, and 15 miles of trails.

"In spite of the fact that this has been one of the driest seasons in years," the project manager said, "livestock in the project show satisfactory gains, both from available grass and improved water conditions. There has been some really remarkable recovery on areas protected during the last 4 years, partly because of grazing protection and partly as a result of two favorable growing seasons."

On the whole, grass seedings have been quite successful. The first were made in the spring of 1936, and all seedings that year and in 1937 gave good stands, with better than average rain. The 1938 fall seedings have had to fight dry weather, but enough grass plants remain to produce a successful stand with a good season. As the area becomes increasingly revegetated, the carrying capacity will increase, resulting in an increase in revenue to the Government and to the county.

Labor for the fence construction, dismantling abandoned farm buildings and other operations is provided by a W. P. A. camp of 100 men near the ghost town of Lamonta, employing Jefferson, Crook, and Deschutes County workers. Popular among the developments thus made possible is the Crooked River recreation area about 14 miles southwest of Madras. The 10 acres of naturally landscaped picnic grounds with table, cooking, water, and other facilities attracted 1,400 cars from mid-April to the Fourth of July.

Reduction in school and road-upkeep costs for the county, provision of better food and shelter for beneficial wildlife in the protected revegetated areas, rodent control, and fire protection are among other benefits reported by Mr. Christenson as resulting from the land-use program.

NOTES ON RECENT DEVELOPMENTS IN THE INFILTRATION PROBLEM

By G. W. MUSGRAVE [1]

IF ALL rainfall could be retained near its point of contact on the land surface there would be no run-off and no erosion; all the rainfall would be conserved, made at least potentially available for plant use. Of course we know, however, that retention of all the water that reaches the earth's surface as rain, snow, or other forms of precipitation is impracticable and might indeed in some instances be undesirable. Yet, generally speaking, a much larger proportion of this precipitation water could be retained with great benefit to the plant and animal life of the globe.

Thus it is extremely important that the rate of infiltration be maintained to an extent sufficient to permit a goodly portion of the rainfall to be retained by the soil. The consumer of water whether an urban or rural dweller, and the consumer of the produce of the land whether such produce is of vegetable or animal origin, have each a vital stake in the matter. The biologist, agronomist, soil technologist, and engineer are concerned likewise, since to a considerable degree they are dependent upon available water for the success of their plans, be those plans for research or for operations on a practical scale. As time goes on and more information is accumulated, additional ways are continually disclosed by which such practices are of further benefit to man.

In the humid regions of the eastern seaboard, the conservation of water is not commonly considered an important problem. Droughts do occur, however, at rare intervals, as during the summer just past, and reservoirs supplying cities with water are depleted and crops are injured. Furthermore, and ignoring these rare droughts, it is very common to find that in certain seasons the crops cease to thrive and show evidence of lack of water. During July and August, pastures become brown and production is limited despite the fact that the annual rainfall is 40 to 50 inches. Technologists thus far have given little thought to the possibility that these seasonal pasture failures may be basically a moisture conservation problem, and that they are the consequence of an excessive drain on water supplies resulting from high evaporation and transpiration at this time of the year. It is interesting to speculate upon what would be the effect were it possible to put into the soil 25 percent more water than today enters our agricultural lands. There is good evidence that in earlier days something of this kind actually did occur: farmers still call the long, slow rain (a large part of which enters the soil) a "million dollar rain."

Of course the problem in the lower rainfall areas is more important, since here shortage of water may be said to represent a chronic condition. Ordinarily in such areas a comparatively small increase in available water results in greatly improved conditions, or it may represent the difference between success or failure of agriculture over a wide region. We usually recognize this situation, while we often overlook the exceedingly common summer shortages in the humid areas.

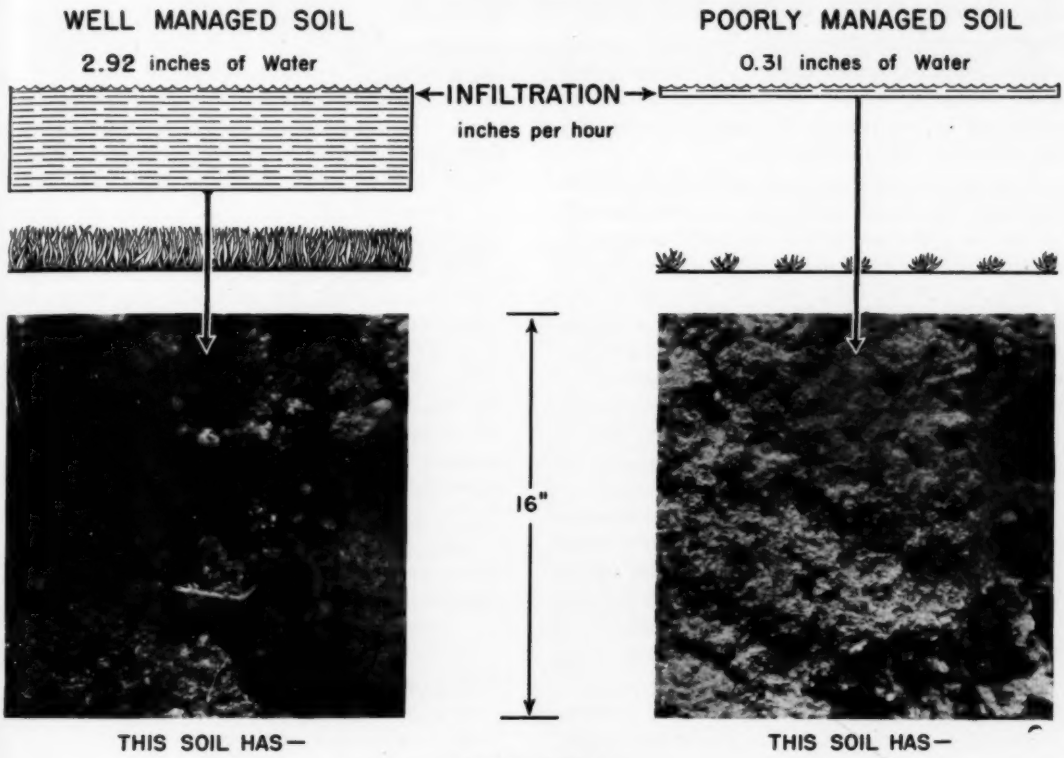
All practical workers know that soils differ widely in their ability to take in water. Farmers know that certain fields may have water standing on them for several days following a rain while other fields take up the rainfall rapidly. A striking example of the differences in infiltration for different soils may be viewed from an airplane on almost any trip soon after a storm. The land surface has a patchy appearance; some of it is covered by water and some is not; some small streams show the recent high-water mark, others do not. The result is a pattern not unlike that of a soils map.

Our Service showed as early as 1933 that the infiltration of Marshall silt loam is much higher than that of Shelby silt loam, though both are soils of the Corn Belt and in the same general climatic region. At the same time it was found, by a comparison of measured amounts of water and soil loss, that the run-off was much greater from the Shelby and likewise that the degree of erosion was much larger. The Davidson and Iredell soils of the Southeastern States are known to differ widely in their rate of water intake. Measurements on Davidson clay loam near Monticello, Ga., and Iredell near Lexington, in the same State, showed, for the two sites studied, infiltration rates of 2.47 inches per hour, and 0.04 inch per hour, respectively.

The interesting and important point which has been established recently is that the method of soil management has a very great effect on infiltration. This is due to the fact that the entrance of water into a soil

[1] Head, infiltration studies, Soil Conservation Service, Washington, D. C.

COMPARISON OF INFILTRATION RATES IN SOILS


WELL MANAGED SOIL
POORLY MANAGED SOIL
2.92 inches of Water
0.31 inches of Water
INFILTRATION
inches per hour
16"
THIS SOIL HAS—
THIS SOIL HAS—
4.37" LARGE PORES (above capillary dimension) 3.20"
44.2% AGGREGATED PARTICLES (2 mm or larger) 24.1%
4.15% ORGANIC MATTER 2.10%
21.1 DISPERSION RATIO 33.9
66.3% SILT AND CLAY (.05 mm) 69.9%
17.2% CLAY (.002 mm) 21.9%

profile is governed largely by the size of the pores; soils having a large amount of pores larger than those of capillary dimension usually have high infiltration rates. Such large pores commonly are associated with a soil structure having the individual particles largely aggregated with soil aggregates behaving like large particles, and with relatively large pores between them. Recent studies also have shown that the state of aggregation is conditioned upon, among other things, a fair quantity of organic matter. In other words, soils high in organic matter, high in aggregation, and consequently having a considerable amount of large pores, have high infiltration rates. Clearly, these are the soils which have been the beneficiaries of good soil management. Conversely, soils which have been intensively cultivated and managed, with inadequate return of crop residues and other forms of organic matter, show these deficiencies in their physical and chemical properties so that the particles are largely nonaggregated and highly dispersed, the pores are of small dimension and the infiltration rate is low. The characteristics of a well managed soil in contrast to a poorly managed soil may be seen in figure 1.

The contrasting conditions portrayed in this figure represent two soils of very similar texture but widely different in structure. The high infiltration is associated with large individual pores, which in turn are associated with nearly twice the amount of aggregated

particles. The high aggregation is associated with nearly twice the amount of organic matter and a considerably lower dispersion ratio. The poor soil, however, has a larger amount of clay and colloid in the subsoil and undoubtedly swells to a greater extent upon addition of water. The measured amount of infiltration for the better soil is 4.03 inches and for the poorer soil is 0.31 inch per hour.

Thus, we are gaining some light on the factors which determine the relative infiltration of different soils. In a study of 68 important soils of the United States, it was found that the principal characteristics affecting infiltration included the amount of noncapillary porosity, the degree of aggregation, the amount of organic matter in the surface soil, and the amount of clay and colloid in the subsoil. The greater the amount of clay and colloid the lower the infiltration, while the greater the amount of organic matter and degree of aggregation, with resulting greater noncapillary porosity, the higher the infiltration.[2]

Other work has shown, of course, additional factors which determine the rate of intake of water by a soil. The degree of turbidity (muddiness) of the surface water is one of these important factors. The presence of forest litter, a straw mulch, or a vegetal cover upon the surface adds greatly to the improvement of the infiltration rate.

These effects are substantiated by actual measurements upon natural soil profiles in the field. Near Chickasha, Okla., two similar areas of Vernon fine sandy loam were compared; the soils differed only in that one had been intensively cultivated and later abandoned, while the other (covered by a dense sod) never had been plowed. Water was applied to the two sites in the form of artificial rain. On the abandoned soil, after 40 minutes of rainfall the infiltration was only 0.28 inch per hour. (See figure 2.) On the corresponding area, however, where the sod had not been plowed and there was a much higher content of organic matter and a higher degree of aggregation (although the profile in general would be described under the term "Vernon fine sandy loam" as was the first soil), the infiltration was 2.95 inches per hour (figure 3). In both instances the sites had received, 24 hours in advance, an application of artificial rain sufficient to bring the rate of run-off to a constant value; thus the infiltration figures cited above are for the soils when thoroughly wet.

Some soils, such as Houston clay, have a very high infiltration in their dry or nearly dry state; but because of their high content of colloid these soils when wet swell to such an extent as virtually to prevent infiltration. While we know of no studies showing definitely that this condition has been improved by treatment, it is reasonable to suppose that this high rate of swelling may be mitigated to some extent by practical treatments, such as the incorporation of organic matter.

In any area there may be operating something of a vicious cycle, if the situation is left uncontrolled. It goes something like this:

(1) Low infiltration followed by poor vegetal cover;

(2) poor vegetal cover followed by high amounts of surface run-off;

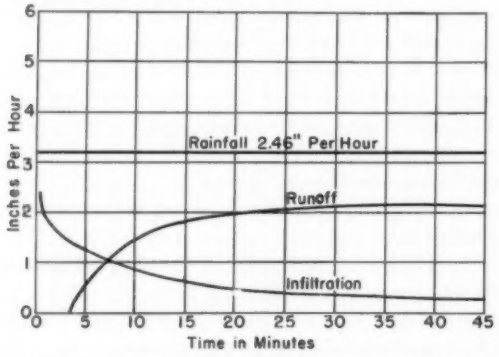
(3) high run-off followed by loss of aggregated and more porous portion of the surface;

(4) loss of porous portion followed by lower infiltration.

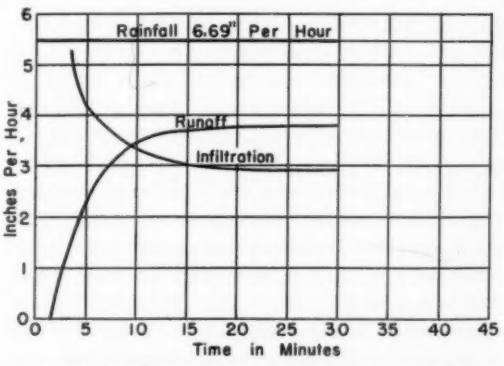
Such a cycle of events probably is quite common, and while there may be exceptions they are relatively infrequent.

Probably the most significant thing that has been learned from recent studies is the very common association between good land use and relatively high in-

[2] The details of this investigation are given in "Relative Infiltration and Related Characteristics of Certain Soils," by G. R. Free, G. M. Browning, and G. W. Musgrave. U. S. Dept. Agr. Tech. Bull. 729.



VERNON FINE SANDY LOAM—ABANDONED LAND



VERNON FINE SANDY LOAM—VIRGIN, PASTURED

BOOK REVIEWS AND ABSTRACTS

by Phoebe O'Neall Faris

REPORT OF THE CHIEF OF THE SOIL CONSERVATION SERVICE, 1939. Office of Superintendent of Documents, United States Government Printing Office, Washington, D. C.

One of the interesting features of the work of our Service is the yearly check-up. This 78-page report by Dr. Bennett is sufficiently complete and sufficiently alive to supply the demands of the most exacting seeker after the facts concerning the operations, objectives and attainments of the S. C. S. during the fiscal year just past.

Those of us who have been working with the Service since the early days of organization cannot but note with satisfaction the definitely solid quality of the Introduction. Here the soil conservation district set-up is reported and explained with minute attention to the details of the basic principles underlying this "new mechanism" which now "takes its place beside the demonstration area" as an important instrument for protective use of the land and water resources of the Nation. "Five years ago the Government, with the cooperation of farmers, was leading the fight against soil waste. Today farmers, with the assistance of the Government, are taking more and more of the initiative, and with a new weapon, the soil conservation district." These two sentences, from the opening paragraph of the report, are most significant, particularly when backed by the June 1939 figures—36 States had passed soil conservation districts laws, and 161 districts had been established and were operating to design, from the ground up, land-use patterns for the stability and permanency of a real agriculture and for improved social and local government functioning.

The soil conservation district set-up, as it has evolved throughout the past 5 years, is defined in detail by Dr. Bennett, from landowners' petition to the State soil conservation committee to the appointment of supervisors and the part of the Service as technical adviser upon request. It should now be plain to all that district organization has been simplified into an easily understandable and easily accessible process, and that farmer initiative is the nucleus around which programs for acceleration of progress in conservation of land and farm or ranch community rehabilitation can be built.

The advantages of soil conservation districts programs, as already noted in many areas, are discussed in considerable detail, while coordination of governmental agencies in providing assistance and advice to the new districts is pointed out as necessary to meet the complexity of problems involved and to avoid stalemate of achievement.

The reorganization of the Department of Agriculture in October 1938 is explained as a further step that has served to speed up the program of the Soil Conservation Service and, following this, figures are given to show the economic results of soil and water conservation.

The report now develops into a division by division, section by section, and unit by unit factual account of the year's work as carried on by the Service in approximately 900 projects and covering more than 200 million acres of land in 47 States and Puerto Rico. Under the main heading "Operations" the extent of work accomplished during the fiscal year is grouped as to farm planning; management of cropland, pastures, orchard and vineyard, range, woodland and wildlife; engineering and roadside erosion control operations; nursery stock and seed furnished for agronomic, woodland and wildlife activities; C. C. C. camp labor; water facilities planning; and surveys and plans for future effective erosion control and land management.

Significant research work at the Service experiment stations is reported as involving studies in rotations, strip cropping and terraces, contour tillage, organic matter applications, soil erodibility, and soil moisture. Other research results, including climatic, physiographic, hydrologic and sedimentation studies and hillculture, drainage and irrigation investigations, are reported as having considerable influence on plans for future operations. Economic investigations, and evaluation studies and field tests as carried on with the cooperation of State agricultural experiment stations, are pointed out as leading to conclusions of importance regarding soil and water conservation practices and crop yields.

Submarginal-land purchase and development is discussed as tentatively planned for land-use adaptations and farm family rehabilitation.

The report closes with a résumé of the surveys and mapping as carried out during the year, and a detailed account of the activities of the information and education division.

NOTES ON INFILTRATION PROBLEM

(Continued from p. 234)

filtration. In test after test it has been found that a type of land use favoring the retention of organic matter in the soil has associated with it a soil structure in which the pores of the soil are relatively large—the individual soil particles being aggregated—and with these conditions there is found high infiltration. Soils having like conditions of silt, clay, colloid, and other constituents but which have been subjected to intensive agriculture, with resulting exhaustion of organic matter, destroyed soil aggregates and the consequent increase in density of structure, mostly have lower infiltration rates than their counterparts which have been well managed.

The effect of a surface mulch in providing a favorable structure where the water first enters the soil has been shown by Duley and Kelly.[3] Many workers in our Service are directly concerned with the advancement of our knowledge of infiltration; and technical workers of many agencies outside the Service appreciate its importance and in numerous instances are directly concerned in the advancement of its special phases. Th next few months doubtless will see a number of important technical papers that will be of interest and assistance to all of us.

[3] Duley, F. L. and L. L. Kelly: Effect of Soil Type, Slope, and Surface Conditions on Intake of Water. Res. Bull. 112. Agricultural Experiment Station, Univ. of Nebraska. May 1939.

FLOOD CONTROL MEASURES ARE CONSERVATION MEASURES

Inundated street in Lindsborg, Kansas. The result of backwater from Smoky Hill River.

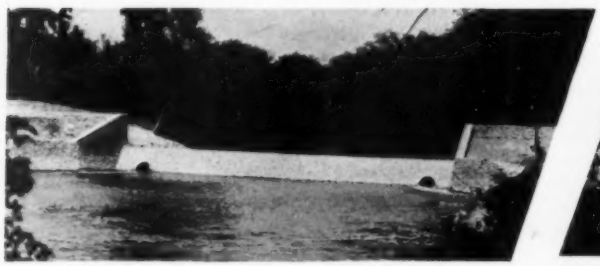
Sand deposit left on valuable cropland in Crittenden County, Ky., by Ohio River flood in January 1937

Deposit of silt and debris from Walton Hollow after a flood in 1932, McGregor, Iowa.

High water on Liberty Street, Bath, N.Y., during a July flood.

Clean streets in McGregor during 1938 flood. A happy result from the application of conservation measures on the watershed and the construction of the Walton Hollow detention reservoir.

Water standing in contour lister ridges in Oklahoma field after a heavy downpour.



Valley City dam project in Barnes County, North Dakota. It was built in 1935.

Streambank control of timber and stone with culvert drain, protecting a highway near Sparta, Wisconsin.

The Canadian River goes out of its bounds in Hemphill County, Texas, October 1935.

U. S. GOVERNMENT PRINTING OFFICE: 1940

SOIL, PLANT, AND LIVESTOCK RELATIONSHIPS

BY A. T. SEMPLE [1]

IN a recent article, W. A. Albrecht, chairman of the Soils Department, University of Missouri, and recently president of the Soil Science Society of America, has pointed out the dangers of depending upon depleted or "sick" soil for the production of forage for livestock. Such soils produce stunted plants that are deficient in essential nutrients such as minerals and proteins. Cows and other stock which must feed on such plants may suffer from deficiency diseases such as "grass tetany" the symptoms of which are similar to milk fever. In the course of robbing their skeletons to produce young and rebuild the bones, deformities develop which may affect the gait.

Doctor Albrecht cites an instance wherein the "analyses of herbage which had defaulted in its support of a cow . . . showed a calcium content of but 0.27 percent and a phosphorus composition of only 0.08 percent. Ordinary wheat straw has 0.21 percent of the former and 0.12 percent of the latter." The herbage consisted of grass with a sprinkling of lespedeza. This illustrates the starvation diet discussed by Moorish in this issue of SOIL CONSERVATION. Usually, in such instances, a mixture of plants such as grasses and legumes provides somewhat better feed than grasses or weeds alone.

In Minnesota, work of Professor Eckles and colleagues showed that cows suffered from "phosphorous deficiencies" when the phosphorous content of alfalfa hay dropped to 0.21; timothy hay to 0.11; and prairie hay to 0.10. The calcium content of these hays respectively was 1.81, 0.39, and 0.44 percent.

In remedying such conditions, it should be kept in mind that the application of the deficient minerals to the soil enables the plants to grow faster, produce more leaves, and yield more forage. In one instance, Dr. Albrecht points out, the application of limestone to lespedeza increased the lime content of the hay almost one-fifth, the phosphorous content one-fifth, and the protein content one-fourth, in addition to the increase in the total yield of dry matter.

Dr. Albrecht concludes in part as follows: "That sick soils will not make healthy animals is particularly significant at this time. We are thinking on a national scale of combating soil erosion by allowing much of the fertility-depleted soil to go back to grass. In our desperate search for varieties of plants that will exist on such soils, perhaps we have given too little thought to whether the forage so grown would be put by the cow on her list of dietary delicacies. . . . Attention to the evidence of soil deficiencies as given by the dumb animals will react with profit both individually and nationally."

The introduction of a plant that will grow on barren sheet-washed slopes, wind-swept fields, and raw gullies, or that will thicken the stand to increase cover and improve forage value of poor, weedy grasses on "sick" soil, often is a necessary measure both ecologically and financially in controlling erosion on critical areas, and is likewise a step in the direction of better land use.

Obviously there is no possibility of satisfactory returns from livestock suffering from deficiency diseases. Where the cost of establishing and maintaining adequate plant food in the soil is prohibitive mineral supplements should be fed to help in warding off deficiency diseases. This practice often is advisable also on soils of low fertility that are in the process of being built up.

The profit to be derived from improved levels of fertility is amply demonstrated on a badly eroded and formerly tax-delinquent field abandoned to briers, at the Western Kentucky Experiment Substation at Princeton. The field was treated with an application of 1½ tons of limestone and 600 pounds of superphosphate and seeded. Over a 10-year period the cash outlay for lime phosphate and seed amounts to about $1.50 per acre per year. The cattle gains have averaged about 80 pounds per acre more on the improved than on the unimproved land. At 5 cents a pound the increased return amounts to $4 per acre per year.

[1] Head, pasture section, division of agronomy, Soil Conservation Service, Washington, D. C.

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The pioneer farmer faced a landscape of prairie grass or other native vegetation from which to carve the farms of the Nation.

(See Mr. Kell's article beginning on the page opposite.)

Fifty years later the landscape changed. Not an acre of grass was left on many farms.